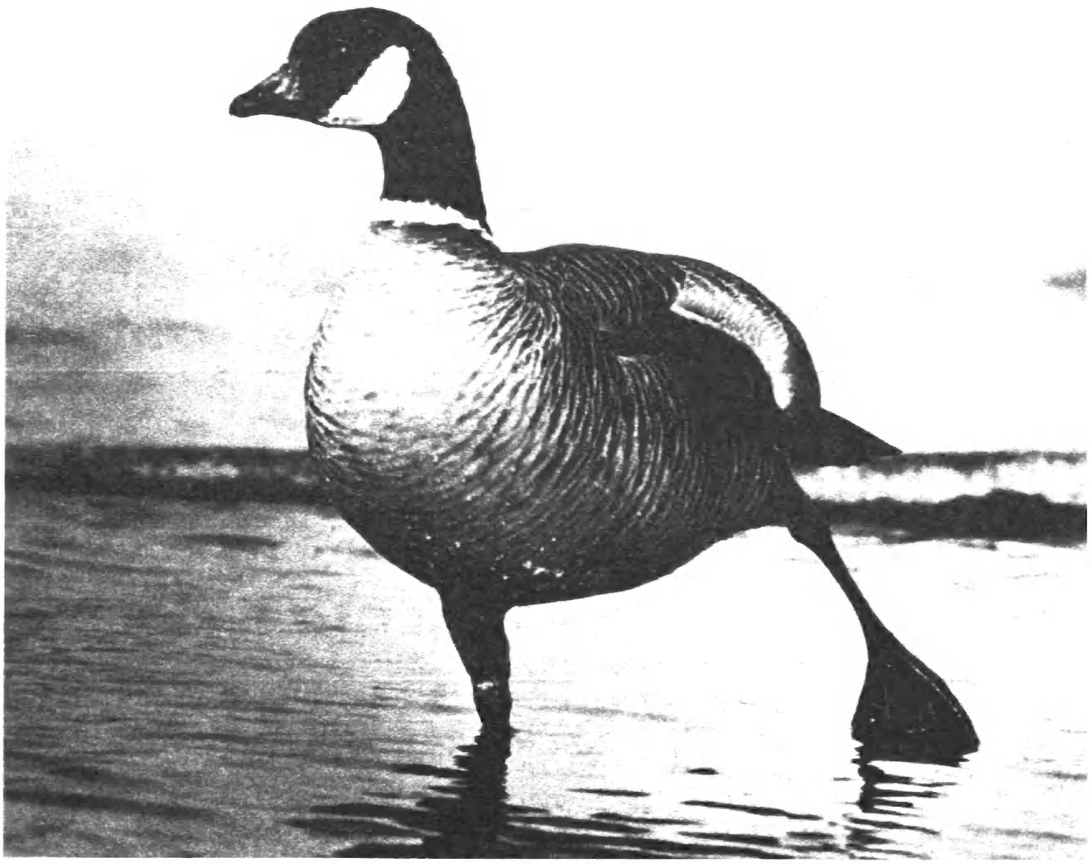
Ecology of Aleutian Canada Geese at Buldir Island, Alaska



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By G. Vernon Byrd
Dennis W. Woolington

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Ecology of Aleutian Canada Geese at Buldir Island, Alaska

by

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Abstract

The only known breeding population of the endangered Aleutian Canada goose (*Branta canadensis leucopareia*) was studied from 1974 to 1977 at Buldir Island, Alaska. Geese began arriving at Buldir in early May; laying peaked during the last week of May or early June. Most eggs hatched in late June or early July and goslings fledged by 21 August. Most geese left Buldir during September. Unlike many other populations of Canada geese, the Aleutian birds did not nest near water. Nest sites were on steep, densely vegetated slopes of the volcanic island, generally below 300 m elevation in two plant communities dominated by tall grasses and forbs. Over 90% of the nests were successful and about 80% of the eggs hatched. Successful pairs raised an average of four goslings each to flight stage. The nesting population of geese at Buldir was estimated to be about 170 pairs. This goose population was increasing rapidly during 1976–77 as a result of hunting closures in California and the age composition was about 20% breeders and 80% immature birds.

The endangered Aleutian Canada goose (*Branta canadensis leucopareia;* Fig. 1) once nested on most of the Aleutian Islands as far east as the Islands of Four Mountains Group (Turner 1886; Clark 1910; Bent 1912; Jochelson 1933; Murie 1959), in the Commander Islands (Stejneger 1885), and in the Kuril Islands (Snow 1897; Fig. 2). As a result of predation by introduced arctic foxes (*Alopex lagopus*) in the Aleutian and Kuril islands and dogs in the Commander Islands, this subspecies was extirpated everywhere except Buldir Island where foxes were never introduced (Murie 1959; Jones 1963; Jones and Byrd 1979).

In 1974 a multifaceted program was initiated to restore the Aleutian Canada goose population to a non-endangered level (Byrd and Springer 1976; Springer et al. 1978). Because of the lack of knowledge about this subspecies, the first requirements of the program were to determine the breeding biology, habitat requirements, and size and structure of the remnant wild breeding population on Buldir. This paper summarizes the results of that study.

Study Area

Location

Buldir (52°21′N, 175°56′E) is in the western Aleutian Islands, Alaska (Fig. 2). The 2,000-ha island, the most isolated of the Aleutians, is about 115 km from the nearest neighboring island. Local place names used in the text are shown in Fig. 3.

Physiography

Buldir is the westernmost Aleutian volcano (Fig. 4) that was active in the late Quarternary or Recent time (Coats 1953). Characteristic physiographic features of the island are boulder-strewn beaches, talus slides, and volcanic peaks. The tallest peak, Buldir Eccentric, rises 655 m above sea level. A relatively flat alluvial deposit, Camp Valley, occurs near Northwest Point; otherwise the island's interior is composed primarily of steep slopes and plateaus. Nearly vertical sea cliffs form over half the island's 20-km-long coastline. The remainder of the coast consists of rockslides, earth slides, or steep vegetated slopes. Buldir has only one relatively large body of fresh water, Kittiwake Pond, with a 1.2-ha surface area. Other surface water includes five ponds less than 15 m in diameter and four small streams that flow all summer. Buldir is about 6.4 km long and 3.2 km wide.

Weather

Weather near sea level at Buldir during the summers is typically cool, humid, cloudy, and windy. During the study, average monthly summer temperatures at the U.S. Weather Service station nearest to Buldir (Shemya Island, 115 km distant) ranged from 3.2° C in May to 9.5° C in August. Our field records at Buldir indicated similar temperatures: average daily maximums and minimums

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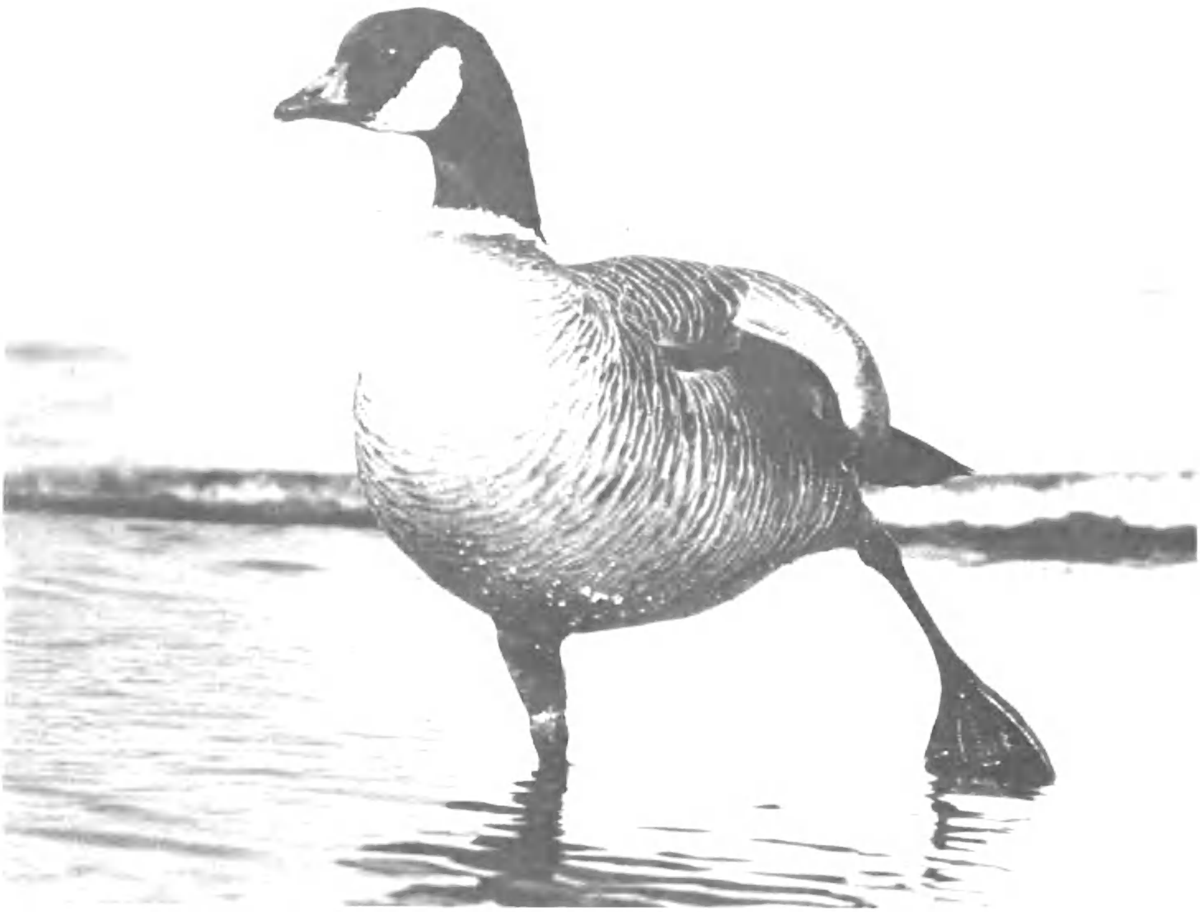

Fig. 1. Adult Aleutian Canada goose. Note broad white ring at the base of the black neck.

ranged from 11° and 5° C in June to 14° and 8° C in August. The average relative humidity near sea level at Buldir ranged from 90.5% in June to 97.4% in August during the study. Precipitation was recorded on 69% of the days in June, 62% in July, and 84% in August. The average monthly precipitation from 1974 to 1976 ranged from 62 mm in June to 131 mm in August. Daily cloud cover averaged 82% in June and just over 90% in July and August. The monthly average wind velocity (1974–76) was about 25 km/h June through August. During the 3 years of the study, spring 1974 was the mildest. That year phenological events (e.g., flower blooming) were earlier than in 1975 and 1976.

Vegetation

The vegetation of the Aleutian Islands is classified as "maritime tundra" (Amundson and Clebsch 1971). Two major vegetative associations or complexes occur at Buldir: the Lowland Tall-plant and the Upland Short-plant (Fig. 5).

The Lowland Tall-plant association, usually below 300 m elevation, was composed of eight plant communities (Byrd 1983). The two most widespread communities were the beach rye–umbel (Fig. 6) and the beach rye–umbel–fern. The former community was dominated by beach rye (*Elymus arenarius*), cow parsnip (*Heracleum lanatum*), and wild celery (*Angelica lucida*). The beach rye–umbel–fern community was similar, but it also contained significant concentrations of *Athyrium felix-femina*.

The Upland Short-plant association, usually above 300 m elevation, contained three communities (Byrd 1983); the most extensive was the moss–willow tundra which contained several species of *Salix*, mosses, and other dwarf plants.

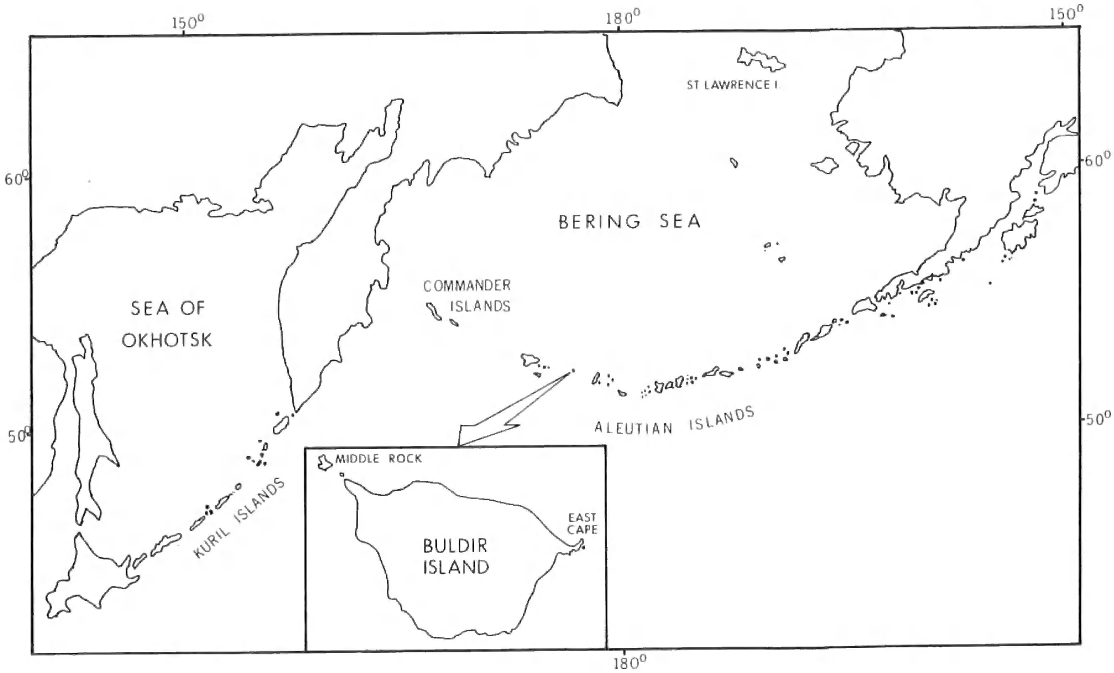

Fig. 2. Aleutian Islands, Alaska, with an enlargement of Buldir Island in inset.

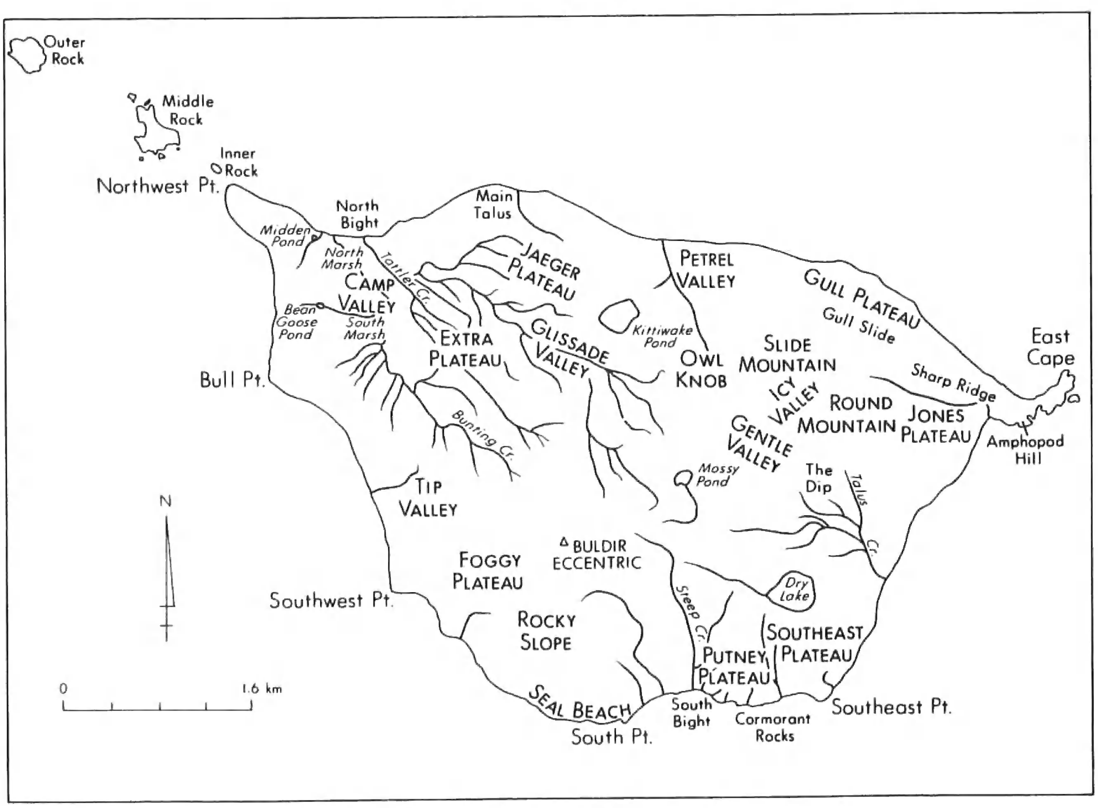

Fig. 3. Buldir Island, Alaska, showing place names.

Fig. 4. Aerial view of the north side of Buldir Island. (Photo by D. H. S. Wehle, 1975)

Fauna

Terrestrial mammals were absent from Buldir, but summer marine mammal populations averaged 5,000 Steller's sea lions (*Eumatopias jubata*), 100 sea otters (*Enhydra lutra*), and 50 harbor seals (*Phoca vitulina*). Buldir supported one of the most diverse seabird nesting colonies in the Northern Hemisphere, with at least 20 breeding species and nearly 2 million birds (Sowls et al. 1978). Aside from Aleutian Canada geese, few breeding waterfowl were found at Buldir, presumably due to absence of suitable nesting habitat. Bald eagles (*Haliaeetus leucocephalus*), peregrine falcons (*Falco peregrinus*), and snowy owls (*Nyctea scandiaca*) bred on the island as did five species of passerines. During spring and fall migration, over 60 species of birds, many of Asiatic origin, were recorded at Buldir (Byrd et al. 1978).

Human Activity

Buldir was once occupied by Aleuts, as indicated by the remains of an Aleut seasonal hunting camp near North Bight (A. P. McCartney, personal communication).

During World War II a small military weather station was constructed on Buldir and up to 12 men were stationed there. Remnants of the camp and related equipment remain. Since World War II, few humans have visited the island.

Methods

Breeding Biology

We were on Buldir from 9 May to 6 September 1974, 17 May to 5 September 1975, 19 May to 28 September 1976,

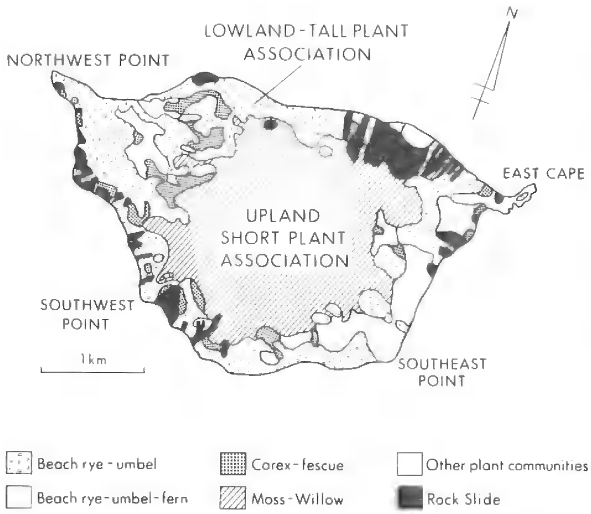

Fig. 5. Buldir Island, Alaska, showing the distribution of associations and plant communities.

Fig. 6. One of the investigators standing in a typical stand of beach rye–umbel. Note height of overstory.

and 25 May to 2 July 1977. Breeding biology data were collected from 1974 to 1976 by two to five researchers who systematically searched vegetated areas that could be reached without technical climbing equipment. In 1977 four researchers censused sample plots to estimate the breeding population.

Canada geese may more readily abandon their nests if disturbed during the early part of incubation than if disturbance occurs later (Hanson and Eberhardt 1971; Cooper 1978); therefore, after 1974, when we learned the general nesting chronology, we conducted searches after geese began incubation. Because researchers in other areas (MacInnis 1962; Mickelson 1975) have reported that young goslings scattered by investigators may be killed by glaucous-winged gulls (*Larus glaucescens*) and parasitic jaegers (*Stercorarius parasiticus*), nest searching was terminated when it was suspected that clutches were near hatching.

Most nests were discovered either by observing incubating geese or by flushing unseen females from nests. Inaccessible slopes were scanned from an Avon sport boat moving along the base of cliffs, or from land through 20 power spotting scopes. At nests, the clutch size was recorded, nest material was noted, and at least two eggs in a sample of nests were floated to determine the stage of incubation ($\pm$ 3 days) by using Westerkov's (1950) method as modified for use with Canada geese (C. J. Lensink, personal communication). Onset of incubation was determined by back-dating. The date of clutch initiation was then determined by subtracting 1 day for each egg in the clutch, plus 1 additional day. This laying rate was used because other populations of small Canada geese that nest at northern latitudes lay one egg per day, but often skip 1 day after egg number four or five in large clutches (MacInnes 1962; Mickelson 1975).

The locations of nests were plotted on 1:25,000 scale maps, and 2-m-long stakes were erected 5 m uphill from nests to facilitate relocation. Nests were rechecked 2–5 weeks after projected hatching dates to determine their fates. Intact egg membranes that had separated from the shells were counted to determine hatching success (cf. Mickelson 1975; Bromley 1976). We considered a nest successful if at least one egg hatched, as did Cooper (1978) and others.

Habitat Use

General Vegetation Analysis

From subjective observations of plant communities in 1974, broad plant associations were mapped by walking over the island's surface and locating boundaries with the aid of a pocket altimeter and compass. U.S. Geological Survey bench marks provided references. Community boundaries were refined in 1975, and the surface area of each plant community was calculated by measuring the map area with a planimeter and then applying a correction factor for slope (determined by estimating the average slope in each community with a simple random sample). In 1975 and 1976 the relative importance (expressed in per-

cent cover) of plant species in each community was determined quantitatively by means of a two-stage systematic sampling design. Strip transects 1 m wide were located randomly in each community from a grid placed over the vegetation map. Randomly chosen 1- × 1-m secondary sample units were replicated as many times as the transect length dictated.

Within each sample unit the vegetation was stratified according to relative height. Overstory was defined as the layer of plants that overshadowed all layers below it. The middle story was the level of plants that overshadowed the ground layer plants, but which was overshadowed by taller plants. Generally, only those plants overshadowed by all other layers were considered in the ground story. The percent coverage of each species was estimated visually in each story. All plant nomenclature followed Hulten (1968).

Vegetation Around Goose Nests

At each goose nest the percentage of coverage of each plant species in each of the height categories was recorded in two quadrats, 1 × 1 m and 5 × 5 m, with the nest as their center. Cover values in the 1- × 1-m nest plots were expanded proportionately to total 100% to compensate for the opening created by the nest. This was necessary to compare data from the 1- × 1-m plots with data from the 5- × 5-m plots around nests and with the 1- × 1-m plots in the communities.

Physical Characteristics of Nest Sites

The slope at each nest was measured with a device called a "distance-height measurer." Physical surroundings were noted, aspects were measured with a compass, and elevation was determined with a pocket altimeter.

Population Size and Structure

Banding

Conventional banding drives (Cooch 1953, 1955) were not possible at Buldir because flightless geese seldom formed large flocks. Instead, birds were in isolated family groups, occasionally including yearlings, or in groups of two to four adults, presumably non-breeders. Geese were captured by hand or with long-handled nets, usually after foot chases. Birds were marked with standard U.S. Fish and Wildlife Service size 7B leg bands and plastic leg bands (34 mm high, 14 mm inside diameter) with color and numerical codes.

Population Estimation

Each fall from mid-August until our departure, we recorded the ratio of banded to unbanded geese and the family group sizes. Plastic leg marker codes were read to determine the presence of known individuals. In 1976 we remained at Buldir later than in previous years, and a Questar field telescope (60× to 130×) made it possible to read plastic leg band codes from a distance of 250 m. Breast and neck plumage (Hanson 1962; Higgins and Schoonover 1969) were used to identify fledglings (fledglings had particularly rufous breasts and small white neck rings).

In 1977 a stratified random sampling design was employed to estimate the number of breeding pairs of geese at Buldir. The goose nesting habitat was divided into four strata (south-facing sea slopes, north-facing sea slopes, inland slopes, and uplands covered by the moss–willow tundra community). Habitats obviously not used for breeding, such as large slide areas, the sparsely vegetated highest elevations, and Camp Valley were excluded from the area sampled. A total of 30 randomly selected 200- × 200-m sample plots were examined. The allocation of plots among strata was weighted to reflect the relative variability of goose nesting density.

The plots were located by visual orientation from map reference and altimeter readings. Boundaries were determined with a compass and a 50-m steel tape. Researchers walked abreast 5–15 m apart over each plot to locate all nests. To aid in future plot location, a 2-m-long aluminum marker, tipped with "day-glow" orange paint, was placed in the most conspicuous corner of the plot.

In addition to surveying the sample plots, we censused two areas, a seaslope near Gull Slide and the Northwest Point peninsula, because their irregular shapes made it impossible to use normal sample plots.

Results and Discussion

Breeding Biology

Arrival of Geese at Buldir

Aleutian Canada geese began arriving at Buldir during the first week of May based on the following observations: (1) in 1974, no geese were seen on 30 April during our initial circumnavigation of the island; (2) on 9 May, our next chance to survey Buldir, 44 geese were counted in an incomplete survey; (3) in 1975 and 1976, geese were present when we arrived on 17 and 19 May, respectively. In the only previous spring survey at Buldir, King (K. W. Kenyon and J. G. King, unpublished report) counted 52 geese on 5 May 1965, on an aerial count he called incomplete.

The early May arrival at Buldir suggests a rapid movement from spring staging grounds. From 1975 to 1978, geese left Crescent City, California, during the last half of April (Woolington et al. 1979).

Most breeders presumably are present by mid-May, 10 to 14 days before laying. The average time between peaks of arrival and nest initiation is 12 days for *B. c. interior* (Raveling and Lumsden 1977) and 10 to 15 days for *B. c. minima* (Raveling 1978; Dau and Mickelson 1979).

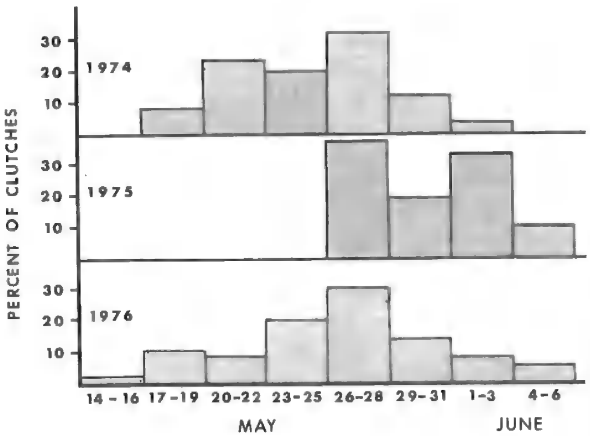

Fig. 7. Distribution of onset of laying dates for Aleutian Canada geese at Buldir Island, Alaska, 1974–76.

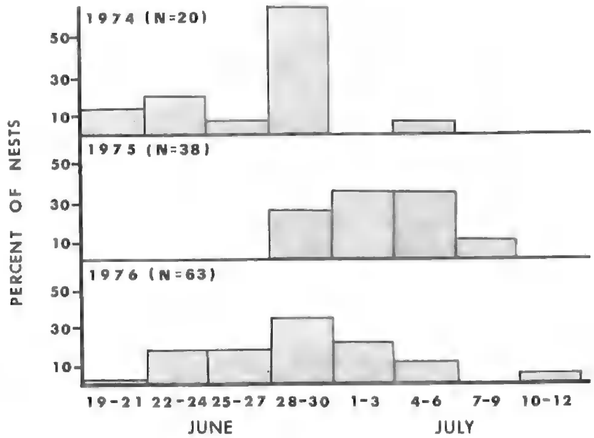

Fig. 8. Distribution of hatching dates for Aleutian Canada geese at Buldir Island, Alaska, 1974–76.

Breeding Phenology

Mean onset of laying ranged from 25 May (1974) to 30 May (1975). All clutches were initiated within a 16-day period in 1974 and within an 11-day period during the late 1975 season. Onset of laying extended for 25 days in 1976, but 92% of the clutches were initiated within an 18-day period (Fig. 7). The ranges in initiation dates, except in 1975, were generally longer than those observed for Canada geese farther north, similar to those at nearly the same latitude, and shorter than those farther south (MacInnes 1962; Vermeer 1970; Hanson and Eberhardt 1971; Mickelson 1975; Bromley 1976; Raveling and Lumsden 1977). In 1975 the range was similar to that of geese nesting 8–9° farther north. On the Yukon–Kuskokwim Delta, Alaska, *B. c. minima* began nesting earlier in 1974 and 1976 than in 1975 (Dau and Mickelson 1979), and on the Copper River Delta, Alaska, *B. c. occidentalis* nested 10 days earlier in 1974 than in 1975 (Bromley 1976).

Extensive snow cover, low temperatures, and violent storms at nesting areas delay the onset of laying in northern breeding geese (Cooch 1958; Mickelson 1975; Raveling and Lumsden 1977; Cooper 1978). The usual effect of a late spring at northern latitudes is to shorten the length of the nesting period (Ryder 1972; Mickelson 1975) as it did at Buldir.

The presence of snow during nest-site selection would probably delay nesting only if it covered the nest site. Elsewhere Canada geese selected nest sites from the first snow-free areas (MacInnes 1962; Mickelson 1975; Bromley 1976). If it is assumed that this phenomenon occurred at Buldir, snow cover was not a significant influence on the timing of laying, but it probably affected the distribution of nests (see *Habitat Use*).

Because no major storms occurred during the period of nest-site selection and laying during our study, temperature may have been responsible for delayed laying in 1975. No records of temperature during the first 3 weeks of May are available for Buldir, but data from Shemya Island indicate that May temperatures in 1975 were lower than in 1974 and 1976. Furthermore, the 1975 average for May was raised by warm weather during the last week of the month. At Buldir this period was also warmer in 1975 than in the other 2 years. An additional indication of the difference in temperatures is the last date freezing temperatures were recorded: 1 May 1974 and 4 May 1976, compared with 25 May 1975.

The incubation period was recorded to the nearest day for only three nests at Buldir: 27, 28, and 29 days. Aleutian Canada goose eggs hatched after 27–28 days (average) in incubators (F. B. Lee, personal communication). Average incubation periods for other Canada geese ranged from 26 to 28 days (Bellrose 1978).

The average hatching dates at Buldir for 1974, 1975, and 1976 were 27 June, 3 July, and 29 June, respectively. Most nests hatched from 19 June to 6 July in 1974 and 1976, but from 28 June to 9 July in 1975 (Fig. 8). Thus, the nesting season (first egg laid to the last egg hatched) was 45–51 days for Aleutian Canada geese. Raveling and Lumsden (1977) discussed nesting periods relative to the size of the goose and the nesting latitude. The Buldir birds nest in about the length of time expected of small Canada geese, using more days than populations at higher latitudes and less than those farther south (cf. Raveling and Lumsden 1977).

Post-hatching Movements

Soon after hatching, Aleutian Canada goose families moved from nest sites to brood-rearing areas which were generally at higher elevations than the nesting areas (see *Habitat Use*), and within 1.5 km of their nests. Similar, but generally longer, movements of broods away from nest

sites have been described by others (Geis 1956; MacInnes 1962; Hanson and Eberhardt 1971; Mickelson 1975; and Bromley 1976).

Non-breeding Adults

At Buldir, flocks of 3 to 40 geese were dispersed over the island, including the breeding areas, during the summer. Marked yearlings and 2-year-olds were included.

One to four geese were observed within several territories of breeding pairs at Buldir. Some groups were tolerated by territorial males but other groups were chased away. Too few observations of marked birds were made to definitely demonstrate that groups tolerated in a particular territory were previous years' young of that breeding pair, but we suspected that was true. Elsewhere, family bonds were usually broken when pairs began active sexual behavior in spring (Hanson and Smith 1950; Balham 1954; Collias and Jahn 1959; MacInnes 1966; Sherwood 1967; Hanson and Eberhardt 1971). Parental intolerance of young usually begins before establishment of nest territories (Collias and Jahn 1959; Hanson and Eberhardt 1971). In some populations most yearlings are excluded from families before adults arrive on the breeding grounds (MacInnes 1966), but in others family breakup occurs after arrival (Sherwood 1967). Yearlings and other non-breeders combine in flocks which usually leave the nesting areas, but in some areas a few may remain (Martin 1964; Sherwood 1967; Hanson and Eberhardt 1971).

Wing Molt

The timing of the wing molt appeared similar in 1974 and 1976, but was slightly later in 1975 (Table 1). Non-breeders were the first to molt. Few flying geese were seen during the last week of July and the first 2 weeks of August, but most adults and young were flying by 22–25 August. The age at which captive reared goslings attained flight was 55 days (F. B. Lee, personal communication), and probably a similar time is required for wild geese at Buldir. The timing of the molt was similar to that recorded for other populations of Canada geese nesting in Alaska (Mickelson 1975; Bromley 1976).

Table 1. *Timing of the wing molt of adult Aleutian Canada geese at Buldir Island, Alaska, 1974–76.*

Event	1974	1975	1976
First flightless birds	18 July	23 July	19 July
Last flying geese before the molt	24 July	30 July	23 July
First flying geese after the molt	18 August[a]	17 August	13 August
Most adults and goslings flying[b]	22 August	25 August	22 August

[a]Fog obscured the area in mid August, so birds were probably flying earlier than the date recorded.
[b]Subjective estimate.

During the wing molt one to three flightless non-breeders (females lacking bare or refeathered brood patches) were frequently found with goslings after a pair of adults, presumably the parents, flushed. Also, isolated groups of two to three flightless non-breeders or failed breeders were found. These observations demonstrate that at least a portion of the non-breeding population of Aleutian Canada geese molted at Buldir.

It is possible that some non-breeding Aleutian Canada geese molted at areas other than Buldir on the basis of the following observations: five geese 10 km west of Buldir flying westerly on 26 July 1975 (G. A. Putney, personal communication), up to 14 geese at Amchitka Island in mid to late June 1977 (F. B. Lee and R. P. Schulmeister, personal communication), and four birds in late June and three in early July 1961 at Amchitka (R. D. Jones, personal communication). It is possible that these were wandering subadults that might have returned to Buldir to molt. If these geese became flightless on most of the islands in the Aleutians, they would have been vulnerable to predation by arctic foxes. In other populations of Canada geese, at least some of the non-breeders migrate to distant molting grounds (Kuyt 1962; Martin 1964; Hanson 1965; MacInnes 1966; Sherwood 1967; Hanson and Eberhardt 1971; Krohn and Bizeau 1979).

Departure of Geese from Buldir

Geese began leaving Buldir during the first week of September in 1976. By 22 September the population was down from an estimated pre-migration total of 1,200–1,400 birds to about 500 geese. By 26 September fewer than 250 geese remained, and when field work terminated on 29 September, fewer than 100 were present. The timing of departure from Buldir in 1976 seemed to be similar to other years on the basis of the few records available (Table 2).

Habitat Use

Availability of Nest Sites

During the middle 2 weeks of May, when most females selected nest sites, the Upland Short-plant association was mostly snow-covered and thus unavailable for nesting. The amount of snow remaining in the Lowland Tall-plant association varied among years. In 1974 the lowland was mostly snow-free during nest site selection, although drifts persisted on north-facing slopes and in shaded gullies or creek banks. About 50% of the lowland was still snow-covered in mid May 1975 and 1976. The percentage of the area that was snow-free increased proportionally with lower elevation, reaching 100% at sea level.

In snow-free areas buttercup (*Ranunculus occidentalis*), red fescue (*Festuca rubra*), and black lily (*Fritillaria camschatcensis*) were the only green plants present during nest site selection. Dried stalks of cow parsnip and wild celery, and hummocks of dried beach rye offered the only

Table 2. *Fall observations of migrating Aleutian Canada geese in the Aleutian Islands, Alaska.*

Date	Location	No. of geese	Source (personal communication)
26 Aug 1965	Amchitka Island	40	R. Wade
4 Sept 1974	At sea east of Shemya Island	40–50[a]	G. Putney
5 Sept 1975	At sea 16 km east of Buldir Island	17	G. Putney
7 Sept 1976	Kiska Island	12	T. Dowell
7 Sept 1976	Unalga Island (east)	34[b]	W. Hoffman
22 Sept 1976	Unimak Island	9[b]	J. Nelson

[a]Probably birds released at Agattu Island in May 1974 (cf. Springer et al. 1978).
[b]Probably *B. c. leucopareia.*

cover. Since Buldir has no lakes in the lowland, timing of freshwater thaw was not important in nest site selection.

In the lowland plant association, the beach rye–umbel and the beach rye–umbel–fern communities covered 68% of the area. The sedge–fescue meadow community accounted for 24% of the association and was confined largely to the higher elevations of the Lowland Tall-plant association, often the transition area between the two associations. Less than 1-ha patches of sedge–fescue meadow were interspersed among the beach rye–umbel and beach rye–umbel–fern communities.

Vegetation Selection for Nest Sites

Geese nested almost exclusively in the beach rye–umbel and beach rye–umbel–fern communities. In both communities geese selected areas with dense concentrations of beach rye in the overstory and red fescue in the middle story (Table 3). The nest territories (5- × 5-m plots) had significantly higher densities of these plants than did the communities at large, and the nest sites (1- × 1-m plots) had significantly higher densities of beach rye, but not red fescue, than did the nest territories (Table 3). There may have been a slight selection against wild celery, and birds clearly avoided areas with high concentrations of cow parsnip at nest sites. Spring beauty (*Claytonia sibirica*) was also avoided. The percentage of fern in the overstory or moss in the ground story was not important in nest site selection.

Beach rye must have been favored for its value as nest cover because dried hummocks provided protection from wind and rain. Green shoots usually appeared by the end of egg-laying (Fig. 9), and by mid to late incubation the new growth provided substantial cover. Beach rye was also the major plant used in nest construction, occurring in all nests. Based on observations of feeding geese and the abundance of cropped stems, red fescue was the major food taken by geese during incubation. It was not favored for nest material, however, and occurred in only 5% of the nests. Cow parsnip and wild celery developed later than beach rye, and their value as nesting cover was relatively low. Furthermore, cow parsnip collected considerable water in

Table 3. *Comparison of percent cover values of major plants at goose nests (1-m² and 25-m² plots) and in plant communities at Buldir Island, Alaska.*

Plant	Story	Percent cover values[a] A – Nest	B – Territory	C – Community	Significant differences[b] A–B	B–C	A–C
Beach rye–umbel		n = 45	n = 45	n = 143			
Elymus arenarius	over	65.6 ± 2.9[c]	45.9 ± 2.7	37.6 ± 0.3	0.001	0.01	0.001
Angelica lucida	over	13.0 ± 1.9	15.8 ± 1.0	16.5 ± 0.2	—	—	0.1
Heracleum lanatum	over	8.7 ± 2.0	20.7 ± 2.1	20.9 ± 0.3	0.001	0.001	0.001
Festuca rubra	middle	32.4 ± 3.0	29.1 ± 2.4	16.9 ± 0.3	—	0.001	0.001
Claytonia sibirica	middle	10.3 ± 1.9	14.8 ± 2.2	22.3 ± 0.3	—	0.01	0.001
Carex macrochaeta	middle	9.5 ± 2.6	11.5 ± 2.1	3.5 ± 0.1	—	0.001	0.05
Moss	ground	32.0 ± 3.9	38.1 ± 3.4	36.1 ± 0.3	—	—	—
Beach rye–umbel–fern		n = 16	n = 16	n = 95			
Athyrium felix-fem	over	33.7 ± 5.5	27.1 ± 4.3	24.4 ± 0.5	—	0.1	—
Elymus arenarius	over	38.0 ± 4.9	29.7 ± 4.1	24.4 ± 0.5	—	0.01	0.001
Angelica lucida	over	12.5 ± 3.9	12.5 ± 1.5	12.9 ± 0.2	—	—	—
Heracleum lanatum	over	9.2 ± 3.8	23.7 ± 2.5	20.6 ± 0.4	0.01	—	0.01
Festuca rubra	middle	30.3 ± 7.7	28.4 ± 4.4	3.4 ± 0.2	—	0.001	0.01
Claytonia sibirica	middle	14.2 ± 4.2	24.4 ± 3.6	40.1 ± 0.5	0.1	0.001	0.001
Moss	ground	33.6 ± 7.9	31.0 ± 5.0	40.4 ± 0.6	—	0.1	—

[a]A = percent cover value (PCV) at nest site (1- × 1-m plot); B = PCV in territory plots (5 × 5 m); and C = PCV in community transect plots (1 × 1 m).
[b]Student's "*t*-distribution" used to calculate highest critical probability at which a significant difference existed (— indicates no significant difference).
[c]Mean ± standard error.
[d]n = number of plots.

Fig. 9. Typical nest of Aleutian Canada goose during early incubation; note young leaves of *Elymus arenarius*. The height of this and other plants would have been considerably greater at hatching.

its leaves and sheaths, which was dumped to the ground during frequent high winds, an undesirable situation at a nest. Spring beauty formed dense, slippery mats which may have made travel difficult for geese.

Physiographic Selection for Nest Sites

Slope. — Of a wide range of physiographic types available (Fig. 10), sea slopes were selected most frequently as nest sites. Essentially all vegetated sea slopes had nesting geese, and the concentration of nests on the south side of the island (Fig. 11) reflected the relatively large area of sea slopes there.

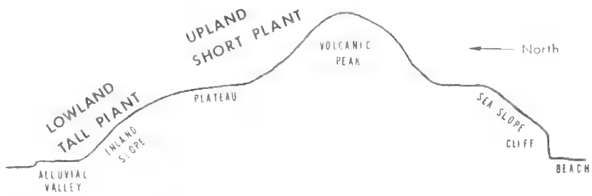

Fig. 10. Cross section of Buldir Island, Alaska, showing physiographic types.

Birds nesting on slopes steeper than 40° had significantly ($P < 0.05$) higher hatching success than those nesting on more gentle slopes (Table 4). Although hatching success seemed to be lowest on slopes of 11–20°, differences in success between pairs using the lower four slope categories (Table 4) were not significant. Nevertheless, the lowest nesting success was also recorded for birds using 11–20° slopes.

Steep slopes were probably selected because they afforded good visibility. Only on these steep slopes would geese be able to view approaching predators over tall vegetation

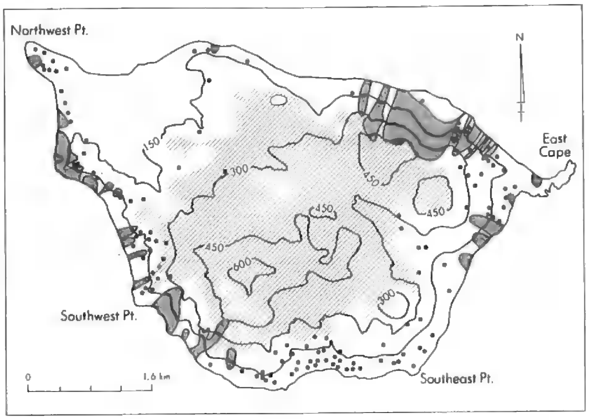

Fig. 11. Distribution of goose nests at Buldir Island, Alaska, 1974–76. Black dots mark nest locations, stippled areas are unvegetated slides, cross-hatching indicates the approximate extent of the Upland Short-plant association, in contrast to the Lowland Tall-plant association where no cross-hatching occurs.

(average, 31.4 cm tall during late incubation). Additionally, over 60% of the nests had a depression of at least 0.5 m within 2 m of the front of the nest, which increased visibility.

Visibility has been recognized by others as an important factor in nest site selection by Canada geese—e.g., *B. c. occidentalis* selected areas of above-average plant densities for nesting except in characteristically dense plant communities where they preferred sites with less than average density (Bromley 1976).

Aspect.—Nesting success was lowest on north-facing slopes where the fewest nests were found (Table 4). The relatively high abandonment by birds nesting on northern exposures may have been related to weather. These areas were more often exposed to severe spring storms, and snow lingered longest there, resulting in less vegetative cover early in the season.

The only significant difference revealed in a comparison of the hatching success of nests on different aspects was lower ($P < 0.05$) success on eastern and southern slopes than on western slopes. This difference is inexplicable and may have been related to factors other than aspect.

Elevation.—Nests ranged from 30 to 320 m in elevation, indicating a broad use of available habitats. The lowest available nesting habitat was usually over 25 m elevation, and areas above 300 m were usually unavailable for nesting because of persistent snow cover.

Above 300 m elevation, a smaller percentage of nests seemed to be successful than at lower elevations, but the sample size of high nests was small (Table 4). No significant differences were found in hatching success in nests at different elevations.

Nesting Density

In 1975 all 45 goose nests we found were in the beach rye–umbel and beach rye–umbel–fern communities, and in 1976, 97% (65 of 67) of the nests were in the same communities. Of the two communities, beach rye–umbel was more widespread at Buldir and contained about 75% of the nests (Table 5).

In 1976 an estimated 138 pairs of geese bred on Buldir (see *Population Size and Structure*). If it is assumed that 133 nests (97% of the total) were in the beach rye–umbel and beach rye–umbel–fern communities and were distributed in the relative proportions indicated by the sam-

Table 4. *Nesting and hatching success of Aleutian Canada goose nests with different slopes, aspects, and elevations at Buldir Island, Alaska, 1974–76.*

Habitat characteristic	Percent of nests	Percent nesting success	Percent hatching success
Slope[a] (n = 128)			
0–10	17	95	79.4 ± 4.6[d]
11–20	09	73	70.8 ± 8.4
21–30	23	86	79.2 ± 3.8
31–40	42	89	83.8 ± 2.7
41–50	09	100	92.8 ± 3.3[e]
Aspect[b] (n = 135)			
338–022 N	09	75	87.6 ± 5.4
023–067 NE	13	91	85.6 ± 3.3
068–112 E	10	92	71.6 ± 6.7[e]
113–157 SE	22	86	82.8 ± 4.4
158–202 S	22	86	75.1 ± 4.4[e]
203–247 SW	14	94	85.5 ± 3.8
248–292 W	08	100	91.0 ± 4.0[e]
293–337 NW	03	100	85.0 ± 9.6
Elevation[c] (n = 142)			
0–60	13	90	87.6 ± 4.2
61–120	35	90	82.2 ± 3.1
121–180	25	92	81.4 ± 3.3
181–240	16	87	81.7 ± 4.9
241–300	07	90	75.3 ± 5.7
301–360	03	75	72.3 ±12.7

[a]Angular degrees from horizontal.
[b]In 44° angular segments centered on compass point.
[c]In meters above sea level.
[d]Mean ± standard error.
[e]Significantly different (student's "*t*-distribution," $P \leq 0.05$).

Table 5. *Estimated density of goose nests in preferred plant communities at Buldir Island, Alaska, 1975–77.*

Community	Percent of combined area	Estimated number of nests 1976	Surface area (hectares)	Nests per hectare[a]
Beach rye–umbel	58.7	100	288	0.35
Beach rye–umbel–fern	41.3	33	203	0.16
Total	100.0	133	491	0.27

[a]Mean nest density per stratum (Column 2 divided by Column 3).

ple, respective densities were 0.35 and 0.16 nest/ha for these two communities. The combined estimate was 0.27 nest/ha (Table 5).

Cooper (1978:34) summarized nest densities of Canada geese at different locations. Of 14 mean nest densities, 9 were lower than Buldir (range 0.02 to 0.25 nests/ha) and 5 were higher (range 0.52 to 12.36).

Brood-rearing and Molting Areas

Soon after hatching, families with Class I goslings (Yocom and Harris 1965) moved inland from nest sites to higher elevations. Most of these areas were at the upper edge of the Lowland Tall-plant association where beach rye–umbel and beach rye–umbel–fern communities provided cover and sedge–fescue meadows and moss–willow tundra provided food. As broods became older, and therefore large enough to be safe from predation by gulls and jaegers, families gradually moved farther from cover. Some flocks of one or two flight-capable adults and one (usually) to four (occasionally) broods were seen in the upland. It seems that flightless adults remained near cover.

Pre-migrational Use Areas

During late August and September, Aleutian Canada geese used the Upland Short-plant association almost exclusively. Based on observations of feeding geese and examination of droppings and cropped stems in feeding areas, favored fall food items appeared to be the fruits of sedge (*Carex* spp.) and crowberry (*Empetrum nigrum*) and the stems of newly emerged, succulent plants of various species. The high plateaus (Dry Lake, Extra Plateau, and Foggy Plateau) and the area around Kittiwake Pond were major feeding areas.

Kittiwake Pond was frequently used for bathing by flocks containing up to 500 birds, including families (occasionally with pre-flight goslings) and non-breeders (marked yearlings and 2-year-olds not associated with families). Geese were seen in salt water only 10 times during the study—just before, during, or immediately after the molt when the birds were probably losing or gaining flight capability.

Population Size and Structure

Production

Clutch size.—Clutches ranged from two to eight eggs, but 82% of them contained five to seven eggs. The overall average was 5.6 eggs with only slight variation among years (Table 6). These clutch sizes may not be exact because our first visit to nests occurred after incubation had begun, and eggs may have already been lost. Moreover, we did not identify or eliminate continuation nests (nests, usually containing smaller clutches, that were started after first clutches are lost; Cooper 1978). These factors probably did not have a major effect on our estimate inasmuch as the average at Buldir was similar to the highest clutch sizes recorded for Canada geese elsewhere (Hanson 1965:165).

Nesting and hatching success.—Data from 1974 were not used to calculate the average nesting and hatching success because, due to inadequate marking, we were unable to relocate 30% of the nests to determine fates. The probability of finding a deserted nest that still contained eggs was much greater than finding a successful nest.

Nesting success in 1975 and 1976 at Buldir was 89 and 93%, respectively. The overall average (91%) is the highest recorded for wild Canada geese (Table 7).

In 1975 and 1976 an average of 74.8% of all eggs hatched (Table 8). Hatching in successful nests (80.7%) averaged only a little higher than that in all nests. The percentage of eggs of unknown fate was higher in 1976 than in 1975, accounting for most of the difference in hatching success.

Fledging success.—Family group counts, conducted from 19 August to 24 September, were used to calculate the fledging success. About four goslings per successful pair of geese reached flight stage at Buldir in 1976 (Table 9). This

Table 6. *Frequency distribution and mean of Aleutian Canada goose clutches at Buldir Island, Alaska, 1974–77.*

Number of eggs	1974	1975	1976	1977	Total
2		1[a] (02)[b]	2 (03)		3 (02)
3	3 (10)		5 (06)		8 (04)
4	2 (07)	4 (09)	7 (09)	7 (19)	20 (11)
5	5 (17)	10 (22)	22 (28)	11 (31)	48 (26)
6	14 (48)	19 (42)	32 (41)	11 (31)	76 (40)
7	5 (17)	9 (20)	10 (13)	6 (17)	30 (16)
8		2 (05)		1 (03)	3 (02)
Total eggs	161	261	419	207	1,048
Total nests	29	45	78	36	188
Mean clutch	5.6 ± 0.2[c]	5.8 ± 0.2	5.4 ± 0.1	5.5 ± 0.2	5.6 ± 0.1

[a]Number of clutches.
[b]Percent in parentheses.
[c]Mean ± standard error.

Table 7. *Percent nesting and hatching success of various populations of Canada geese.*

Subspecies	Nesting success	Nests destroyed by predators	Nests deserted	Hatching success, all nests	Hatching success, successful nests only	Source
B. c. hutchinsii and *parvipes*				75–90[a]		MacInnes 1962
B. c. moffitti	70	12	14	65	89	Hanson and Browning 1959
B. c. moffitti	51–73	16–28	11–17	62	86–90	Geis 1956
"large race"	27–80	14–50	4–21		77–90	Vermeer 1970
B. c. occidentalis	32–83	15–65	3–4	28–67		Bromley 1976
B. c. occidentalis				80		Trainer 1959
B. c. maxima	65–82	5	11	67		Cooper 1978
B. c. interior	78–83	17–22	1		78–85	Raveling and Lumsden 1977
B. c. minima	72	28				Eisenhauer and Kirkpatrick 1977
B. c. minima	65	28		68		Mickelson 1975
B. c. leucopareia	91		9	75	81	This study

[a]All values rounded to nearest whole percent.

Table 8. *Fate of Aleutian Canada goose eggs at Buldir Island, Alaska, 1975–76.*

Fate	1975		1976		Both years	
	Number of eggs	Percent of total	Number of eggs	Percent of total	Number of eggs	Percent of total
Hatched						
All nests	204	78.2	276	72.5	473	74.8
Successful nests		86.1		77.1		80.7
Fate unknown[a]	28	10.7	67	18.1	97	15.3
Deserted[b]	13	5.0	14	3.8	27	4.3
Infertile[c]	8	3.1	14	3.8	22	3.5
Embryo death[c]	8	3.1	6	1.6	14	2.2
Total eggs	261		371		632	

[a]Eggs recorded when nests were found that were not accounted for during rechecks. Possible explanations include predators carrying eggs away from nests, scavenging gulls removing membranes of hatched eggs, and wind blowing membranes from nests.
[b]Eggs left in nests where no eggs hatched.
[c]Eggs left in successful nests.

Table 9. *Family group counts of Aleutian Canada geese at Buldir Island, Alaska, August–September 1976.*

	Number of fledglings per pair							Total families	Fledglings per family
	1	2	3	4	5	6	7		
Number of families	9	28	66	49	66	31	6	255	3.99 ± 0.008[a]

[a]Mean ± standard error.

family group size is large compared with other populations: 3.7 and 3.2 for *B. c. maxima* at Seney National Wildlife Refuge (calculated from G. A. Sherwood, unpublished report), 3.0 and 2.8 for the same subspecies in Colorado (calculated from Szymczak 1975), and 3.7 for *B. c. minima* on the Yukon–Kuskokwim Delta, Alaska (Mickelson 1975).

For our method of calculating fledging success to be accurate, individual broods must be distinguishable. Several flocks containing multiple broods were recorded at Buldir, but most flightless groups were probably intact on the basis of the uniform weights and stage of plumage development of the young.

Groupings of broods have been recorded in other Canada goose populations (Williams and Marshall 1937; Miller and Collins 1953; Naylor 1953; Geis 1956; Sherwood 1967; and Hanson and Eberhardt 1971); yet MacInnes (1962) and Mickelson (1975) did not consider brood flocks common in the populations of small northern Canada geese they studied. Hanson and Eberhardt (1971) observed mixing mainly after goslings were 4–5 weeks old. Geis (1956) suggested crowded conditions in the rearing areas might increase brood flocking.

A comparison of the average number of goslings per brood (3.99) with the average number of goslings hatched per successful pair (4.2) indicates a maximum gosling survival rate of 95%. The actual rate might have been lower because the fate of over 18% of the eggs in 1976 was unknown. The low hatching to fledging mortality (5%) at Buldir is probably caused by the absence of mammalian predators and the abundance of buffer prey species for avian predators. Canada goose gosling survival rates of 90% or greater were found at four of the six locations cited by MacInnes (1962).

There has been considerable discussion about the use of family group counts to estimate waterfowl production. Sherwood (1967) found that pairs with grouped broods remained together in winter and exhibited family behavior. He pointed out that counts of such assemblages would bias estimates of productivity. In a different study area, Raveling (1969) demonstrated that families of Canada geese remained intact in winter, and Raveling and Lumsden (1977) presented the rationale for using such counts to predict production.

We believe that most broods at Buldir were probably with their own parents when they fledged. We make this assumption on the basis of observations of color-marked birds, the size of broods (one to seven goslings per family), and the behavior of groups (alighting together) thought to be families (Raveling 1968).

Mortality Factors—Eggs

Loss of entire clutches.—Predation of nests in Canada geese is highly variable, with losses ranging from 5.0 to 64.6% in most populations (Table 7). No Aleutian Canada goose nests were found completely destroyed by predators; desertion accounted for all the unsuccessful nests (9%). This rate is intermediate compared with other populations (Table 7). In 1974 one nest was lost in an earth slide, a potentially serious hazard on the unstable volcanic island.

Loss of partial clutches.—Glaucous-winged gulls were observed eating goose eggs once, and 10 eggs with large holes like those expected after gull predation (Mickelson 1975) were also found. Gulls are also known to swallow whole eggs (D. Raveling, personal communication). Most eggs with holes were found away from nests and would have been recorded as "unknown fate." A comparison of hatching success of goose nests at various distances from gull concentrations (e.g., gull nesting colonies and loafing areas) indicates no significant differences, but nesting success increased slightly as the distance from gulls increased (Table 10). Abundant prey items were available to gulls; they took at least eight species of birds, several species of fish, insects, and berries (Trapp 1979).

Table 10. *Nesting and hatching success of Aleutian Canada geese at various distances from glaucous-winged gull colonies, Buldir Island, Alaska, 1975–76.*

Distance to gull colony (m)	Number of nests	Nesting success (%)	Number of nests	Hatching success[a] (%)
0–50	70 (56)[b]	87	63 (56)	81
51–100	34 (27)	91	29 (26)	80
Over 100	21 (17)	95	20 (18)	77
Total	125		112	

[a]Successful nests only.
[b]Percentage of total in parentheses.

Herring gulls (*Larus argentatus*), glaucous gulls (*L. hyperboreus*), glaucous-winged gulls, and parasitic jaegers were major predators of goose eggs at other areas (Barry 1956; Angstadt 1961; MacInnes 1962; Mickelson 1975; Bromley 1976; Raveling and Lumsden 1977). Proximity of geese to areas frequented by predators (Cooper 1978), abundance of buffer prey species (Angstadt 1961), and disturbance of incubating geese by humans (MacInnes 1962; Mickelson 1975) are factors that affect predation rates.

Mortality Factors—Goslings and Adults

Predation.—We were unable to directly assess the extent of gull and jaeger predation on young goslings because we avoided the nesting areas from onset of hatching until most broods were 2–3 weeks old. Nevertheless, we saw a gull pick up and drop, apparently unharmed, a Class Ib gosling, and a parasitic jaeger was seen diving at a brood of Class Ib goslings.

On the Yukon-Kuskokwim Delta, Alaska, most losses of *B. c. minima* goslings occurred during their first 2 weeks of life (Mickelson 1975). In the same study, parasitic jaegers were able to take only Class Ia goslings and were not important predators. Gulls and jaegers affected goslings similarly in the Northwest Territories (MacInnes 1962).

Bald eagles occasionally took flightless goslings at Buldir. Food remains from the single active eagle eyrie were examined periodically throughout the summer and fall of 1974 and 1975, and the remains of only one goose was found, a banded gosling in 1975. Three wings of adult geese were found in an eagle eyrie at Buldir in 1963 (Jones 1963). As many as five eagles hunted geese frequently in early to mid September after most other prey species had left Buldir. The fresh remains of five molting geese killed by eagles were found during the study, and old bones and wing feathers of 10 geese were also found. Peregrine falcons and snowy owls may have taken geese, but no direct evidence was found.

Diseases and accidents. — Diseases and accidents are not usually considered important in breeding Canada geese, and they were not major causes of mortality during our study. Nevertheless, these factors were examined at Buldir because of the endangered status of the goose.

In 1975 goslings captured at Buldir to replenish captive stocks were heavily infested with *coccidia* when they arrived at the Patuxent Wildlife Research Center, Laural, Maryland (R. Erickson, personal communication). Analysis of goose droppings subsequently collected at Buldir in 1975 showed that a high percentage of the wild birds were carrying *coccidia* (J. Carpenter, personal communication). Apparently under normal conditions the birds suffer no detrimental effects, but under the stress conditions incurred during shipping, the parasitic infection overwhelmed them. It is not known if conditions of stress occur in the wild sufficient to induce coccidiosis.

A female with a bare brood patch was found dead in June 1976. Necropsy indicated the bird died from generalized peritonitis caused by a ruptured egg in the oviduct (L. N. Locke, personal communication).

Two goslings that had apparently fallen from the slope above were found dead on a Buldir beach (K. W. Kenyon, unpublished report). In 1975 we found a dead Class Ic gosling with a swelling and discoloration in the area of the wrist. The injured bird may have died from infection.

In 1976 we saw at least 11 geese that were either limping or dragging a leg in flight. We captured two recently fledged goslings that were either injured as a result of an accident or had been hit by predators. One had a broken ulna, the other a crippled foot. Perhaps accidents occur while goslings are learning to fly. We observed some possibly injurious landings made by fledglings during high-velocity, gusty winds.

1976 Populations

To estimate the number of Aleutian Canada goose fledglings produced at Buldir Island in 1976, we used the formula of Ricker (1958) —

$$N = \frac{M(C + 1)}{R + 1}$$

where N = estimate of the total population of fledglings

M = number of goslings marked with color bands in 1976 (105)

C = total number of fledged goslings seen on census (962)

R = number of color-marked fledged goslings seen on census (197)

and calculated that

$$N = \frac{105\ (962 + 1)}{197 + 1}$$

$$N = 510 \text{ fledglings.}$$

Given an average brood size of 3.99 (Table 9), 128 breeding pairs produced young. Since 93% of all nesting pairs were successful in 1976, 138 pairs laid clutches.

Given an April 1976 population estimate of 900 Aleutian Canada geese (Woolington et al. 1979), and no correction factor for the unknown amount of adult mortality from April to September, the 1976 production would have increased the number of geese to 1,410. A population estimate of 1,200 to 1,400 geese was derived from flock counts at Buldir during the last week of August 1976. This estimate is similar to the count of 1,280 Aleutian Canada geese, thought to include the entire population, made 12 November 1976 in California (Springer et al. 1978). If 1,300 is used as the pre-migration population at Buldir, the age structure was 21.2% breeders, 39.5% non-breeding yearlings and adults, and 39.3% fledglings (Table 11).

1977 Populations

Using statistical sampling for the first time at Buldir, we estimated that 171 ± 13 (confidence interval 90%) pairs of geese nested in 1977 (Table 12). It was not possible to collect data on nesting, hatching, and fledging success in 1977, so averages from previous years were used to estimate production and the fall population.

Based on the average nesting success for 1975 and 1976 (91%) and the average fledglings per pair (3.99), 156 pairs (91% of 171) raised 622 fledglings in 1977. The fall population of geese at Buldir would have been 1,770 if the 1977 production were added to the April 1977 population census in California (1,150 geese; Woolington et al. 1979). We subjectively reduced the estimate to 1,700 geese to compensate for mortality that occurred at an unknown rate from April to September. In spite of the suppositions used to reach this estimate, it seems reasonable since 1,630 was the peak fall 1977 Aleutian Canada goose population in California (Woolington et al. 1979). The age structure of the pre-migration population at Buldir based on these calculations was 19.6% breeders, 44.8% non-breeding yearlings and adults, and 35.6% fledglings (Table 11).

Population Trends

The pre-migration Aleutian Canada goose population was calculated to have increased 30.8% between 1976 and 1977 (1,300 to 1,700 birds). Presumably the age structure also changed during the study.

The population increase and accompanying change in age structure of Aleutian Canada geese is attributed to reduced mortality resulting from hunting closures on Canada geese initiated in 1975 in Aleutian Canada goose concentration areas in California to protect this endangered subspecies (Springer et al. 1978). Fledglings sustain disproportionately high mortality from hunting (Moffitt 1935; Chapman et al. 1969) which may explain the especially high increase (13.4%) in the non-breeding yearling and adult age categories into which the 1976 fledglings would enter

Table 11. *Age structure of fall Aleutian Canada goose populations at Buldir Island, Alaska, 1976–77.*

Age class	1976 Total birds	1976 Percent of population	1977 Total birds	1977 Percent of population
Breeders	276	21.2	342	19.6
Non-breeding adults	514	39.5	783	44.8
Fledglings	510	39.3	622	35.6

Table 12. *Estimate of breeding pairs of Aleutian Canada geese in four sampling strata and census areas at Buldir Island, Alaska in 1977.*

	North-facing sea slopes	South-facing sea slopes	Inland Tall-plant slopes	Moss–willow tundra	Sub-total	Census areas[a]	Total
Total sample plots	3	20	5	2	30	2	32
Total nests found	0	20	1	0	21	12	33
Average nests per plot	0	1[b]	0.2[c]	0			
Average nests per hectare	0	0.25	0.05	0			
Area in stratum (hectares)	150	560	370	510	1,590	10	1,600
Estimated total pairs	0	140	19	0	159[d]	12	171

[a]The census plot by Gull Slide (eight nests) and the 1974–76 average number of nests at Northwest Point (four nests) are added.
[b]Confidence Interval (CI) = 0.45 (90% level).
[c]CI = 0.31 (90% level).
[d]CI (for all strata) = ± 12.8 nests (90% level).

by spring 1977 (Table 11). The trend would be for the non-breeding yearling and adult category to increase at a proportionally higher rate until cohorts that have benefited particularly from hunting closures reach the breeding age.

Management Implications

Knowledge of the nesting chronology, types of habitat used, and the size and age structure of this population of endangered geese will allow managers to direct and evaluate the results of management efforts. The sample plots for estimating nesting density may be rechecked in the future to determine trends in the population.

The rapid increase in Aleutian Canada geese, after hunting was reduced, demonstrates that Buldir had a capacity to support more geese than were present at the beginning of our study. Ultimately, nest sites may become limiting at Buldir, but it would be worthwhile to determine the nesting densities that could occur before that happens.

The increased population at Buldir provides stock for transplanting to other islands from which introduced foxes have been removed (Springer et al. 1978). Goslings could also be used to restock captive flocks used in the restoration project.

Epilogue

Since the end of our field studies in 1977, the U.S. Fish and Wildlife Service and the State wildlife agencies in Alaska, California, and Oregon have continued a cooperative recovery program for the Aleutian Canada goose. Measures taken thus far include fox control in the Aleutian Islands, captive propagation of geese and their release, transplanting wild geese from Buldir to other islands, and closures to Canada goose hunting in the wintering grounds. As a result of this combined effort, the Aleutian Canada goose fall population had increased to an estimated 2,600 birds by 1983 (P. F. Springer, personal communication). In addition, a second Aleutian Islands breeding location, containing a small population of geese, was recently discovered (J. L. Trapp and E. P. Bailey, personal communication). The Aleutian Canada goose seems to be on a firm road toward recovery.

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